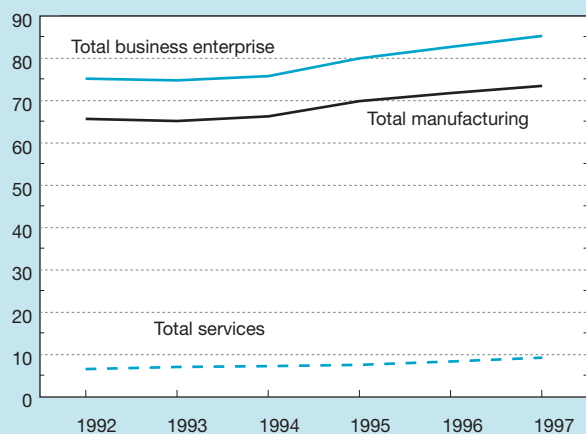


Figure 6-21.
European Union industrial R&D performance:
1992–97

Billions of current PPP \$



Top industrial R&D performers and share of total industrial R&D (percents)

	1987	1992	1997
Data not available		Chemicals 19.5	Chemicals 20.7
		Motor vehicles 13.7	Motor vehicles 14.7
		Electronic equipment 10.7	Electronic equipment 12.8
		Aerospace and other transport equipment 10.7	Total services 10.9
		Machinery, N.E.C. 8.8	Aerospace and other transport equipment 8.9

PPP = purchasing power parity; N.E.C. = not elsewhere classified

See appendix table 6-11. *Science & Engineering Indicators – 2002*

Patented Inventions

Inventions have important economic benefits to a nation because they often result in new or improved products, more efficient manufacturing processes, or even new industries. To foster inventiveness, nations assign property rights to inventors in the form of patents, which allow the inventor to exclude others from making, using, or selling the invention. Inventors can obtain patents from government-authorized agencies for inventions judged to be new, useful, and not obvious.

Although the Patent and Trademark Office (PTO) grants several types of patents, this discussion is limited to utility patents only, which are commonly known as patents for inventions. Patenting indicators have several well-known drawbacks, including the following:

- ◆ **Incompleteness.** Many inventions are not patented at all, in part because laws in some countries already provide for the protection of industrial trade secrets.
- ◆ **Inconsistency across industries and fields.** Industries and fields vary considerably in their propensity to patent inventions; thus, comparing patenting rates among different industries or fields is not advisable (Scherer 1992).
- ◆ **Inconsistency in quality.** The importance of patented inventions can vary considerably, although calculating patent

citation rates (discussed later in this section and in chapter 5) is one method for mitigating this problem.

Despite these and other limitations, patents provide a unique source of information on inventive activities. Patent data provide useful indicators of technical change and serve as a means of measuring inventive output over time.²¹ In addition, information on U.S. patenting by foreign inventors enables measurement of the inventiveness in those foreign countries (Pavitt 1985) and can serve as a leading indicator of new technological competition (Faust 1984).²²

U.S. Patenting

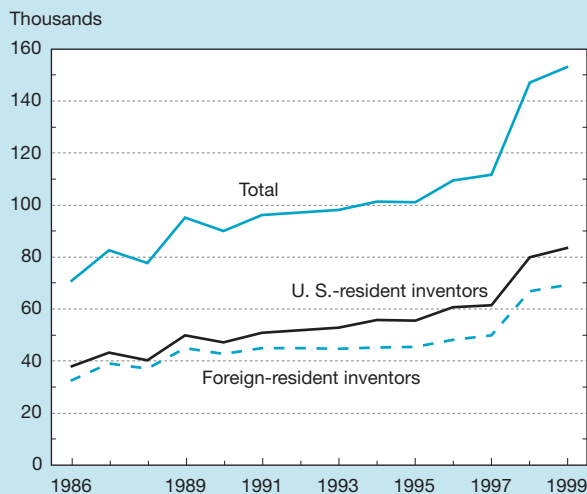
In 1999, more than 153,000 patents were issued in the United States, 4 percent more than that granted a year earlier. This new record number of patents caps off nearly a decade of growth during the 1990s. In 1995, U.S. patents granted fell just short of the previous year's mark, but the upward trend resumed with small increases in U.S. patents granted in 1996 and 1997 before a 32 percent jump in 1998.²³ (See figure 6-22 and appendix table 6-12.)

²¹See Griliches (1990) for a survey of literature related to this point.

²²It should also be noted that there is concern that patents and other forms of intellectual property may discourage research, its communication, and the diffusion of new technologies. The question arises whether in some respects the extension of intellectual property rights have proceeded too far. To provide answers to guide IPR policy over the next decade and beyond, the Science, Technology and Economic Policy Board (STEP) of the National Research Council (NRC) has undertaken a project to review the purposes of the IPR legal framework and assess how well those purposes are being served. The Board will identify whether there are current or emerging problems of inadequate or over-protection of IPRs that need attention and will commission research on some of these topics.

²³Although patent applications have been rising, PTO attributes most of the increase in 1998 to greater administrative efficiency and the hiring of additional patent examiners.

Figure 6-22.
U.S. patents granted: 1986–99



See appendix table 6-12. *Science & Engineering Indicators – 2002*

Patents Granted to U.S. Inventors

During the mid-1980s, the share of U.S. patents awarded to U.S. inventors began to decline. Although some observers were concerned that this downward trend indicated a decline in U.S. competitiveness, patenting by U.S. inventors increased by the end of the decade, outpacing patenting by foreign inventors. This upward trend has continued throughout the 1990s, and in 1999, U.S. inventors were awarded nearly 84,000 new patents, an increase of about 4.5 percent over 1998. (See figure 6-22.)

Inventors who work for private companies or the Federal Government commonly assign ownership of their patents to their employers; self-employed inventors typically retain ownership of their patents. Therefore, examining patent data by owner's sector of employment can provide a good indication of the sector in which the inventive work was done. In 1999, corporations owned 80 percent of granted patents.²⁴ See sidebar, "Top Patenting Corporations." This percentage has gradually increased over the years.²⁵

After business entities, individuals are the next largest group of U.S. patent owners. Before 1986, individuals owned, on average, 24 percent of all patents granted to U.S. inventors.²⁶ Their share has fluctuated downward since then, to a low of 19 percent in 1999. The Federal share of patents averaged 3.3 percent of the total during the period 1963–85, eventually falling to 1.1 percent in 1999, the lowest level ever.²⁷ U.S. Government-owned patents were encouraged by legislation enacted during the 1980s that called for U.S. agencies to establish new programs and increase incentives to their scientists, engineers, and technicians for the transfer of technology developed in the course of government research.²⁸

²⁴About 2.2 percent of patents granted to U.S. inventors in 1999 were owned by U.S. universities and colleges. PTO counts these as being owned by corporations. For further discussion of academic patenting, see the chapter 5 section, "Patents Awarded to U.S. Universities."

²⁵From 1987 to 1997, corporate-owned patents accounted for between 77 and 79 percent of total U.S.-owned patents. Since 1997, corporations have increased their share each year and, by 1999, represented 82 percent of total U.S.-owned patents.

²⁶Before 1986, data are provided as a total for the period 1963–85.

²⁷Federal inventors frequently obtain a statutory invention registration (SIR) rather than a patent. The SIR is not ordinarily subject to examination and is less costly to obtain than a patent. Also, the SIR gives the holder the right to use the invention but does not prevent others from selling or using it as well.

²⁸The Bayh-Dole University and Small Business Patent Act of 1980 permitted government grantees and contractors to retain title to inventions resulting from federally supported R&D and encouraged the licensing of such inventions to industry. The Stevenson-Wydler Technology Innovation Act of 1980 made the transfer of federally owned or originated technology to state and local governments and to the private sector a national policy and the duty of government laboratories. The act was amended by the Federal Technology Transfer Act of 1986 to provide additional incentives for the transfer and commercialization of federally developed technologies. In April 1987, Executive Order 12591 ordered executive departments and agencies to encourage and facilitate collaborations among Federal laboratories, state and local governments, universities, and the private sector—particularly small business—to aid technology transfer to the marketplace. In 1996, Congress strengthened private-sector rights to intellectual property resulting from these partnerships.

Patents Granted to Foreign Inventors

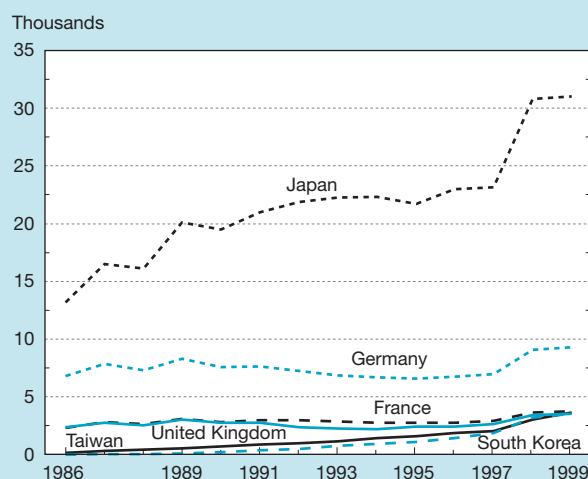
Foreign-origin patents represented 45 percent of all patents granted in the United States in 1999, a share maintained since 1997.²⁹ During much of the 1980s, foreign-origin patents increased at a faster rate than U.S.-origin patents, reaching a peak of 48 percent of all U.S. patents in 1989. From the following year until 1996, U.S. inventor patenting increased at a faster pace than that of foreign inventors, dropping the foreign share to 44 percent. In 1999, two countries (Japan and Germany) accounted for just more than 58 percent of U.S. patents granted to foreign inventors. The top four countries (Japan, Germany, France, and the United Kingdom) accounted for about 70 percent. (See figure 6-23 and appendix table 6-12.)

Although patenting by inventors from the leading industrialized countries has leveled off or even declined, some Asian economies, particularly Taiwan and South Korea, have stepped up their patenting activity in the United States and are proving to be strong inventors of new technologies.³⁰ Between 1963 (the year data first became available) and 1985, Taiwan was awarded just 742 U.S. patents. During the 14-year period since then, Taiwan was awarded more than 19,000 U.S. patents. U.S. patenting activity by inventors from South Korea shows a similar growth pattern. Before 1986, South Korea was awarded just 213 U.S. patents; since then, it has been awarded more than 14,000 new patents. In 1998, Taiwan and South Korea surpassed Canada to become the fifth and sixth most active foreigner inventors in the United States. Sweden and the Netherlands also had large increases in U.S. patenting in 1998.

²⁹Corporations account for about 80 percent of all foreign-owned U.S. patents.

³⁰Some of the decline in U.S. patenting by inventors from the leading industrialized nations may be attributed to the move toward European unification, which has encouraged wider patenting within Europe.

Figure 6-23.
U.S. patents granted to foreign inventors, by
residence of inventor: 1986–99



NOTE: Selected economies are the top six recipients of U.S. patents during 1999.

See appendix table 6-12. Science & Engineering Indicators – 2002

Top Patenting Corporations

A review of the top patenting corporations in the United States during the past 25 years illustrates the technological transformation achieved by Japan over a relatively short period. In 1973, no Japanese companies ranked among the top 10 patenting corporations in the United States. In 1983, however, 3 of the top 10 were Japanese companies. By 1993, Japanese companies outnumbered U.S. companies, and in 1996, 7 of the top 10 were Japanese companies. The most recent data (1999) show a South Korean company (Samsung Electronics Company), 3 U.S. companies, and 6 Japanese companies among the top 10. (See text table 6-2.) Samsung ranked 4th among patenting corporations in the United States in 1999 after ranking 17th just two years earlier. South Korea's U.S. patenting now emphasizes computer, television and communications, and power generation technologies. Despite their economic problems, South Korea and Japan have achieved continued success in patenting inventions in the United States, illustrating their growing ability to innovate in important technologies.

IBM was awarded more patents than any other U.S. organization in 1999, the seventh consecutive year that the company has earned this distinction. Lucent Technologies joined the top 10 for the first time with 1,153 patents, nearly a quarter more than it received just a year earlier. The only other U.S. company making the top 10, Motorola, dropped from fourth to eighth place with 1,192 patents in 1999, more than 200 fewer than it received in 1998.

Text table 6-2.

Top patenting corporations

Company	Patents
1999	
International Business Machines Corp.	2,756
NEC Corporation	1,842
Canon Kabushiki Kaisha	1,795
Samsung Electronics Co., Ltd.	1,545
Sony Corporation	1,409
Toshiba Corporation	1,200
Fujitsu Limited	1,193
Motorola, Inc.	1,192
Lucent Technologies	1,153
Mitsubishi Denki Kabushiki Kaisha	1,054
1977-96	
General Electric Corp.	16,206
International Business Machines Corp.	15,205
Hitachi Ltd.	14,500
Canon Kabushiki Kaisha	13,797
Toshiba Corporation	13,413
Mitsubishi Denki Kabushiki Kaisha	10,192
U.S. Philips Corporation	9,943
Eastman Kodak Company	9,729
AT&T Corporation	9,380
Motorola, Inc.	9,143

SOURCE: U.S. Patent and Trademark Office, Information Products Division, Technology, Assessment, and Forecast Branch, special tabulations (November 2000).

Science & Engineering Indicators – 2002

Trends in Applications for U.S. Patents

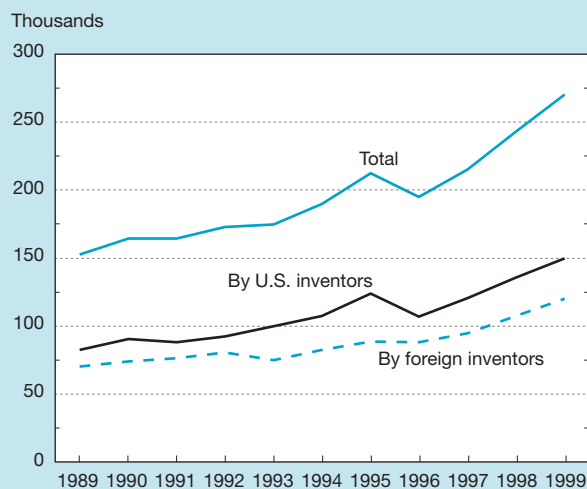
The review process leading up to the official grant of a new patent may take as long as 2 years. Consequently, the examination of year-to-year trends in patents granted will not always reveal the most recent changes in patenting activity. The number of patent applications filed with the PTO provides an earlier, albeit less certain, indication of changes to patterns of inventiveness. Yet, current trends in new patent applications help to revise observations made from the more informative data, presented earlier, on trends in U.S. patents granted.

Patent Applications From U.S. and Foreign Inventors

Applications for U.S. patents reached 270,000 in 1999, an increase of about 11 percent over 1998. These latest data extend what has been nearly a decade of annual increases. During the past 11 years, the only significant decline in patent applications occurred in 1996. (See figure 6-24 and appendix table 6-13.)

U.S. resident patents represented 56 percent of all patents applied for in the United States in 1999, a share maintained since

Figure 6-24.
U.S. patent applications: 1989-99



See appendix table 6-13. *Science & Engineering Indicators – 2002*

1997. Because patents granted to foreign inventors have generally accounted for about 45–47 percent of total U.S. patents granted, it appears that the success rate for foreign-origin patents is lower than that for those applied for by U.S. inventors.

In 1999, two countries, Japan and Germany, accounted for nearly 44 percent of U.S. patent applications made by foreign inventors. Although patent filings by inventors from the leading industrialized countries have leveled off and have even begun to decline, other countries, particularly Asian countries with the exception of Japan, have stepped up their patenting activity in the United States. This is especially true for Taiwan and South Korea, and the data on recent patent applications indicate that this trend continues.

Since 1997, residents of Taiwan and South Korea have distinguished themselves in the number of applications for U.S. patents. In 1997, the number of patents applied for by residents of Taiwan and South Korea ranked them among the top five for the first time, replacing residents from France and Canada. Residents of Taiwan had moved up further in 1998 to become the third leading source for new U.S. patent applications. In 1999, residents of Taiwan applied for more than 9,000 new patents, an increase of 27 percent from a year earlier and more than 2,400 than that made by residents of the United Kingdom, ranked fourth. If recent patents granted to residents of Taiwan are indicative of the technologies awaiting review, then many of these applications will be for new computer and electronic inventions. Compared with the rising trend in Taiwan's U.S. patent applications, recent filings by inventors from South Korea have not continued at the same pace.

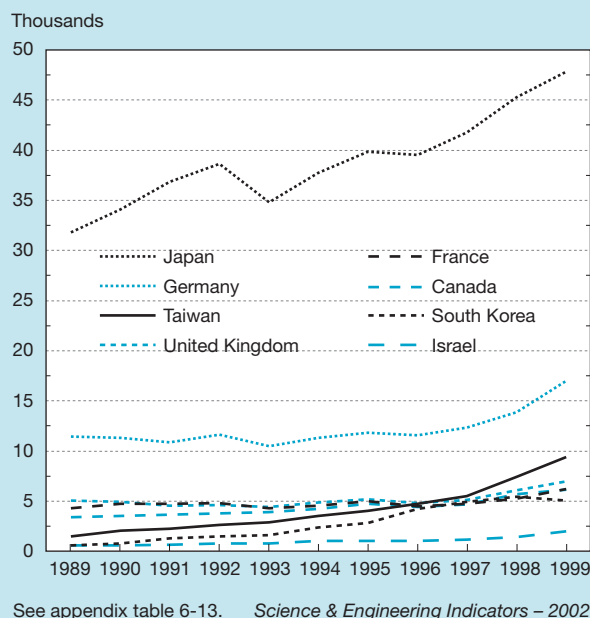
Although less dramatic than that demonstrated by inventors from Taiwan and South Korea, patent applications by inventors from Germany, France, and Israel also increased in 1999. Inventors residing in Israel were particularly active, increasing their applications for U.S. patents by about 39 percent from a year earlier. (See figure 6-25.)

Technical Fields Favored by U.S. and Foreign Inventors

A country's distribution of patents by technical area is a reliable indicator of both its technological strengths and its focus on product development. This section compares and discusses the various key technical fields favored by U.S. inventors and the top five foreign inventors patenting in the United States.³¹ Patent activity in the United States by inventors from foreign countries can be used to identify a country's technological strengths as well as U.S. product markets likely to see increased competition.

³¹Information in this section is based on PTO's classification system, which divides patents into approximately 370 active classes. With this system, patent activity for U.S. and foreign inventors in recent years can be compared by using an activity index. For any year, the activity index is the proportion of patents in a particular class granted to inventors in a specific country divided by the proportion of all patents granted to inventors in that country. Because U.S. patenting data reflect a much larger share of patenting by individuals without corporate or government affiliation than do data on foreign patenting, only patents granted to corporations are used to construct the U.S. patenting activity indices.

Figure 6-25.
U.S. patent applications filed by selected foreign inventors, by residence of inventor: 1989–99



Fields Favored by U.S. and Leading Foreign Inventors

Although U.S. patent activity encompasses a wide spectrum of technology and new product areas, U.S. corporations' patenting emphasizes several technology areas expected to play an important role in the nation's future economic growth (U.S. Office of Science and Technology Policy 1997). In 1999, corporate patent activity reflected U.S. technological strengths in medical and surgical devices, electronics, telecommunications, advanced materials, and biotechnology. (See text table 6-3.)

The 1999 patent data show not only Japan's continued emphasis on photocopying, photography, and consumer electronics technology but also its broader range of U.S. patents in information technology. From improved information storage technology for computers to visual display systems, Japanese inventions are earning U.S. patents in areas that aid in the processing, storage, and transmission of information.

German inventors continue to develop new products and processes in technology areas associated with heavy manufacturing, a field in which it has traditionally maintained a strong presence. The 1999 U.S. patent activity index shows that Germany emphasizes inventions for motor vehicles, printing, new chemistry and advanced materials, and material-handling equipment.

In addition to inventions for traditional manufacturing applications, British patent activity is also high in biotechnology and chemistry. Like the British, the French are quite active in patent classes associated with manufacturing applications and biotechnology. They share the emphasis of U.S. inventors in aeronautics and communications technologies.

Text table 6-3.

Top 15 most emphasized U.S. patent classes for corporations from United States, Japan, and Germany: 1999

United States	Japan	Germany
1. Surgical instruments	Information storage and retrieval	Plant protecting and regulating compositions
2. Biology of multicellular organisms	Television signal processing	Clutches and power-stop control
3. Surgery: light, thermal, and electrical applications	Photocopying	Printing
4. Wells	Electrophotography	Brake systems
5. Data processing	Photography	Metal deforming
6. Digital processing systems	Liquid crystal cells	Bodies and tops for land vehicles
7. Information processing system organization	Crystal growth processes	Winding, tensioning, or guiding devices
8. I/O digital processing systems	Interrelated power delivery controls	Internal combustion engines
9. Surgery (medicators and receptors)	Facsimile	Bleaching and dyeing of textiles
10. Business practice, dataprocessing	Incremental printing of symbolic information	X-ray or gamma-ray systems
11. Computer memory	Music	Machine element or mechanism
12. Computer processing architectures	Brake systems	Electrical transmission systems
13. Aeronautics	Typewriting machines	Land vehicles
14. Electronic digital logic circuitry	Radiation imagery chemistry	Power plants
15. Surgery	Internal combustion engines	Organic compounds

I/O = Input/output

NOTES: Ranking is based on patenting activity of nongovernment U.S. or foreign organizations, which are predominately corporations. Patenting by individuals and governments is excluded.

SOURCE: U.S. Patent and Trademark Office, Office of Information Services, TAF Program, 2001.

Science & Engineering Indicators – 2002

As recently as 1980, Taiwan's U.S. patent activity was concentrated in the area of toys and other amusement devices. By the 1990s, Taiwan was active in communications technology, semiconductor manufacturing processes, and internal combustion engines. The data from 1999 show that Taiwan's inventors have continued to broaden their technology portfolio, emphasizing testing and measuring devices, audio systems, advanced materials, optics, and aeronautics.

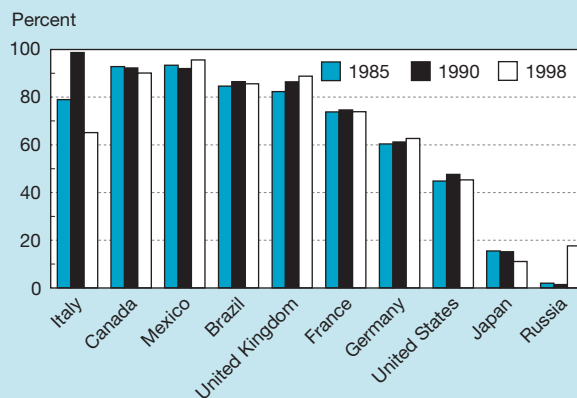
U.S. patenting by South Korean inventors has also reflected that country's rapid technological development. The 1999 data show that South Korean inventors are patenting heavily in television technologies and a broad array of computer technologies that include devices for dynamic and static information storage, data generation and conversion, error detection, and display systems. (See text table 6-4.)

Both South Korea and Taiwan are major suppliers of computers and peripherals to the United States, and recent patenting data show that their scientists and engineers are developing these new technologies and improving existing ones. These new inventions are likely to enhance their competitiveness in the United States and in the global market.

Patenting Outside the United States

In most countries, foreign inventors account for a much larger share of total patent activity than in the United States. When foreign patent activity in the United States is compared with that in 11 other countries in 1985, 1990, and 1998, only Russia and Japan consistently had smaller shares of foreign patent activity. (See figure 6-26.)

Figure 6-26.
Share of total patents awarded to nonresident inventors in selected countries



See appendix tables 6-12 and 6-14.

Science & Engineering Indicators – 2002

Although much attention is given to the level of foreign patenting in the United States, this tends to overshadow the success of U.S. inventors in patenting their inventions around the world. In 1998, U.S. inventors led all other foreign inventors not only in countries neighboring the United States but also in markets such as Germany, Japan, France, Italy, Brazil, Russia, Malaysia, and Thailand. (See figure 6-27 and appendix table 6-14.) Japanese inventors edge out Americans in China and dominate foreign patenting in South Korea. German inventors are also quite active in many of the other countries examined.

Text table 6-4.

Top 15 most emphasized U.S. patent classes for corporations from South Korea and Taiwan: 1999

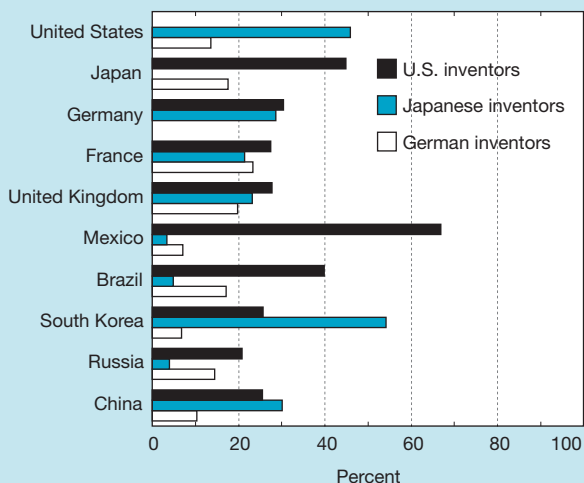
South Korea	Taiwan
1. Transmission systems	Semiconductor device manufacturing process
2. Liquid crystal cells, elements and systems	Electrical connectors
3. Refrigeration	Solid state devices
4. Static information storage and retrieval	Music
5. Power delivery controls	Circuit makers and breakers
6. Television signal processing for recording	Substrate etching processes
7. Television	Receptacles
8. Semiconductor device manufacturing process	Electrical systems and devices
9. Dynamic magnetic information storage or retrieval	Chairs and seats
10. Electric heating	Computers
11. Miscellaneous active electrical nonlinear devices	Illumination
12. Electric lamp and discharge devices	Electrical power conversion systems
13. Electric lamp and discharge systems	Static information storage and retrieval
14. Active solid-state devices	Supports
15. Electric power conversion systems	Coded data generation

NOTE: Ranking is based on patenting activity of nongovernmental organizations, which are primarily corporations. Patenting by individuals and governments is excluded.

SOURCE: U.S. Patent and Trademark Office, Office of Information Services, TAF Program, 2001.

Science & Engineering Indicators – 2002

Figure 6-27.
Patents granted to nonresident inventors in selected countries: 1998



See appendix table 6-14. Science & Engineering Indicators – 2002

International Patenting Trends in Two New Technology Areas³²

This section explores the relative strength of America's inventiveness by examining international patenting patterns in two new technology areas: human DNA sequences and business methods. The analysis is built around the concept of a "patent family," i.e., all the patent documents published in a

³²Information presented in this section was developed by Mogee Research & Analysis Associates under contract to the National Science Foundation. (See Mogee April 2001 and Mogee June 2001).

country associated with a single invention. See sidebar, "International Patent Families As a Basis for Comparison."

Three indicators are used here to compare national positions in each technology area:

◆ **Trends in international inventive activity.** This indicator is a preliminary measure of the extent and growth of inventive activity considered important enough to be patented outside the country of origin. These data are tabulated by priority year.

◆ **Number of organizations assigned patents.** The number of organizations in a country that are active in a technology may indicate a country's ability to innovate and its potential for innovative activity. Research by Michael Porter (1990) suggests that the growth of clusters of innovative organizations is associated with national competitiveness. The Council on Competitiveness (2001) also associates clusters of innovation with higher rates of innovation, productivity growth, and new business formation.

◆ **Highly cited inventions.** Interpatent citations are an accepted method of gauging the technological value or significance of different patents. These citations, provided by the patent examiner, indicate the "prior art" (the technology in related fields of invention) that is taken into account in judging the novelty of the present invention.³³ The number of citations a patent receives from later patents can serve as an indicator of its technical importance or value.

³³The citations counted are those placed on European Patent Office (EPO) patents by EPO examiners. EPO citations are believed to be a less biased and broader source of citations than those of PTO. See Claus and Higham (1982).